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INVESTIGATION OF ULTRASONIC WELDING OF REFRACTORY METALS AND ALLOYS

November 1962

Prepared under Navy Bureau of Naval Weapons
Contract No. NOw 63-0125-c

Bimonthly Progress Report No. 1
16 August 1962 through 16 October 1962

AEROPROJECTS INCORPORATED
WEST CHESTER, PENNSYLVANIA

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ABSTRACT

Preliminary specifications for Power-Force Programming (PFP) control circuits and the tentative design for a system have been established. PFP components have been secured, and a 4-kilowatt spot welder has been modified to operate with them. Efforts have been expended in securing an adequate source of refractory metals, and probative meetings have been established with manufacturers relative to material composition and processing techniques.

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INVESTIGATION OF ULTRASONIC WELDING OF REFRACTORY METALS AND ALLOYS

This program on ultrasonic welding of refractory metals is concerned with the application of Power-Force Programming (PFP) during the weld interval to increase the generation of quality welds in these refractory metals on a reproducible basis. The program is divided into four parts:

1. Power-Force Programming Equipment: Modification of earlier feasibility-study devices to provide for predetermined automatic power and force variation over the weld interval, utilizing a suitably-modified 4-kilowatt ultrasonic spot-type welder.

2. Evaluation of Welding With Power-Force Programming: Study the effect of the application of PFP, using materials of known ultrasonic weldability, such as stainless steel and a high-nickel alloy.

3. Welding Refractory Metals With Power-Force Programming: Using molybdenum - 0.5 percent titanium, study PFP welding parameters productive of sound, high-strength welds. Ascertain the maximum thickness of this alloy that can be welded with and without PFP.

4. Apply Power-Force Programming to Two Additional Refractory Metals: These metals to be niobium alloy and commercially pure tungsten.

Although the contract documents are dated 16 August 1962, the executed contract was received on 27 November 1962. Only planning and minor investigative efforts were carried out during the period to 16 October 1962.

The work carried out during this period is as follows:

Power-Force Programming Equipment

Initial feasibility studies involving power programming were achieved by sequential operation of three interval timers with the relays of each timer wired into the welder power-control circuit so that three discrete power steps were achieved during pre-selected portions of the weld interval. Force programming was achieved manually by varying the force control valve during the weld interval.

Preliminary specifications for the PFP control circuits and a tentative design for the system were established. Necessary components were procured and assembled for incorporation into a spot welder. Sub-assemblies of this system have been tested, and some of the response characteristics determined.

Power-Force Programming equipment consists of a peg-board-type master-control panel, transistorized variable delay relays for the time base control circuit, function control relays for directing the signals for power and force control, a servo-amplifier, feedback pressure transducer, and servo-valve for force control.

The peg-board-type control panel provides a matrix system of ten increments for the preset levels of power and force along the ordinate, and from five to ten increments for the selected weld interval along the abscissa which always represents the total value of the weld interval as set on the master interval timer, thus providing decimal stepwise variation of power and force over any portion of the weld interval.

Power is controlled by relays coupled to variable resistors in the oscillator output circuit. Force is controlled by the magnitude of the signal delivered to a precalibrated servo-amplifier which in turn controls a servo-valve in the hydraulic force system.

As indicated, these components were obtained for incorporation into a welding machine. An existing 4-kilowatt spot welder was modified to operate with these PFP components for a preliminary evaluation.

The work to be carried out under this contract will utilize a 4-kilowatt welder. In order to deliver the energies which will be involved within the normal weld intervals, high-response circuitry will not be required with PFP operative. The high-response requirements contribute to considerably more expensive control components than are currently demanded. Accordingly, Table I contains the specifications tentatively established as necessary for the PFP circuitry to effectively carry out the requirements of this phase of the refractory metals welding program.

A review of weld impedance data obtained for copper and aluminum* reveals a relatively slow change during the weld interval, indicating that provision for five steps in the clamping-force system will probably be adequate. Accordingly, the first system will be with five (5) steps only in the force system, and ten (10) steps in the power control system.

Weldment Materials

Weldment materials are not specified for the investigatory effort. Enough is known**, however, about the deleterious effect of material impurities and variations due to heat treatment on the ultrasonic welding of refractory metals to warrant continuation of effort along these lines.

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* Jones, J. Byron, N. Maropis, J. G. Thomas and D. Bancroft, "Fundamentals of Ultrasonic Welding, Phase II". RR-60-91, Final Report on Contract NOas 59-6070-c, December, 1960.

** Aeroprojects Incorporated, "Ultrasonic Welding of Refractory Metals", Progress Report No. 9, Contract NOw-61-0410-c, October 1962.

As a result, purity requirements and processing standards may be established, and an adequate source for refractory metals determined.

Communication has been established with manufacturers, and several meetings have been scheduled to attempt to isolate the problem, and to procure requisite materials.

Future Work

During the forthcoming period, the following work will be initiated:

1. A Power-Force Program circuit will be assembled and partially evaluated. Final specifications will be determined, and necessary components will be obtained.

2. Several meetings will be arranged with manufacturers of the refractory metals of interest to the program, and specifications for these materials, both as to composition and fabrication techniques, will be established if practical. Sample lots of each alloy will be ordered.

Table I

TENTATIVE SPECIFICATIONS FOR
POWER-FORCE PROGRAMMING CIRCUIT

Time Base	Specified Time (seconds)
Five Step Time Control	
Step Wise Variable	0 to 5.0
Response Through Control Relays	0.005
Power Control	
Electronic Power Source Only	0.005*
Force Control	
Hydraulic (Servo-Valve or Parallel By-pass Solenoids)	
Rise	0.050
Decay	0.030

* Permits use of standard relays.

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